WATER OPERATION AND MAINTENANCE BULLETIN

No. 197 September 2001

IN THIS ISSUE. . .

UNITED STATES DEPARTMENT OF THE INTERIOR **Bureau of Reclamation**

Available on the Internet at: **http://www.usbr.gov/infrastr/waterbull**

This *Water Operation and Maintenance Bulletin* is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Bureau of Reclamation personnel and water user groups in operating and maintaining project facilities.

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For further information about the *Water Operation and Maintenance Bulletin* or to receive a copy of the index, contact:

Jerry Fischer, Managing Editor
Bureau of Reclamation
Inspections and Emergency Management Group
Code D-8470
PO Box 25007, Denver, Colorado 80225-0007
Telephone: (303) 445-2748
FAX: (303) 445-6381
Email: jfischer@do.usbr.gov

***Cover photograph**:* *Damaged joint showing rusted area.*

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A LOW-COST AUTOMATED FARM TURNOUT FOR BETTER WATER MANAGEMENT

by Blair L. Stringam,[1] Brian W. Sauer,[2] and Clifford A. Pugh[3]

Abstract

A low-cost automated farm turnout was designed to maintain constant turnout flow rates from canal delivery systems to individual farm fields. Low-cost, off-the-shelf components were combined to fabricate this device. The cost of all the components totaled less than $2,300. All of these components work together to maintain turnout flow rates to the specified amount plus or minus 4 percent error. These turnouts are recommended for canal systems where the canal levels typically fluctuate throughout the day. Presently, four of these automated turnouts have been installed; three on farms near Boise, Idaho, and one in Yuma, Arizona.

Introduction

Irrigation demands, environmental concerns, and urban growth continue to fuel the need for efficient operation of water delivery systems. In many river systems, in-stream flow requirements are being increased to preserve wildlife, aquatic ecology, and the surrounding habitat. In irrigation districts, water management is becoming more challenging as irrigators realize that crop yields can be maximized if sufficient amounts of water can be delivered at the proper time.

As irrigation districts try to be more responsive to water users, they are finding that water losses are increasing and the canal systems are becoming harder to manage. Supply and lateral canals are often subject to water level and turnout delivery fluctuations. These fluctuations and losses are due to the fact that the canal systems were originally designed for rigid delivery schedules. The consequence of these fluctuations is that individual farms receive too little or too much water. These flow variations can reduce crop yields, damage soil, and waste water.

Understanding that canal system fluctuations will occur, tools can be provided that minimize this problem. If farm turnouts automatically adjust to maintain constant deliveries, irrigation

[1] Hydraulic Engineer, Bureau of Reclamation, Water Resources Research Laboratory, PO Box 25007 (D-8560), Denver, Colorado 80225; bstringam@do.usbr.gov

[2] Water Conservation Specialist, Bureau of Reclamation, Snake River Area Office, 214 Broadway Avenue, Boise, Idaho 83702; bsauer@pn.usbr.gov

[3] Technical Specialist-Hydraulic Engineer, Bureau of Reclamation, Water Resources Research Laboratory, PO Box 25007 (D-8560), Denver, Colorado 80225; cpugh@do.usbr.gov

districts can be much more responsive to user demand changes. If the amount of water delivered to the turnout can more closely match the demand, administrative spills and delivery shortages will be reduced.

Background

Recent work at the Bureau of Reclamation Water Resources Research Laboratory (WRRL) has focused on the development and testing of a low-cost device that can be used by irrigation districts and farmers to regulate diverted water to individual farm turnouts. This automated farm turnout (AFT) consists of low-cost components that can be used to maintain a near constant delivery to individual farm fields. The individual components need to be robust because western irrigation districts are subject to environmental conditions that are harsh on automation equipment (Stringam et al., 1999). The canal environment subjects electrical equipment to heat, humidity, debris, vegetation, dust, lightning, and vandalism. The automation equipment must endure these conditions and still be reliable and accurate. Presently, few farm turnouts are automated because there are no low-cost, reliable devices available.

Instrumentation Under Investigation

The AFT consists of three primary components as well as peripheral measurement devices. These components include a linear actuator, a turnout gate, and a low-cost controller (i.e., central processing unit or CPU). Several CPU devices were considered for this application, with costs ranging from \$100 to \$2,000. The lower-cost CPUs require additional components, including an LCD screen and switches as well as additional fabrication costs. The total price of the less expensive CPUs with the additional fabrication costs came to about \$300. When the lower-cost CPUs were tested, they exhibited some minor compiler problems, and it was feared that these problems would escalate in the field. The most expensive CPUs suited the application, but they were not selected because of their higher cost. A CPU that cost about \$420 was finally chosen for this application (figure 1).

Figure 1.—Control box showing CPU, interface electronics, and battery.

The selected CPU is an industrial process controller that can be programed in C and assembly languages. It is manufactured with a built-in LCD and keypad, which minimized fabrication and assembly costs. The LCD and keypad give the operator the capability of displaying flow rates, displaying total amounts of diverted water, and changing flow set points. The CPU is programmed to receive feedback from a water-level sensor which is located downstream of the turnout control gate. It also receives feedback from a gate position sensor. Various types of sensors will work with this controller—all that is required is that the sensor outputs a voltage or current signal.

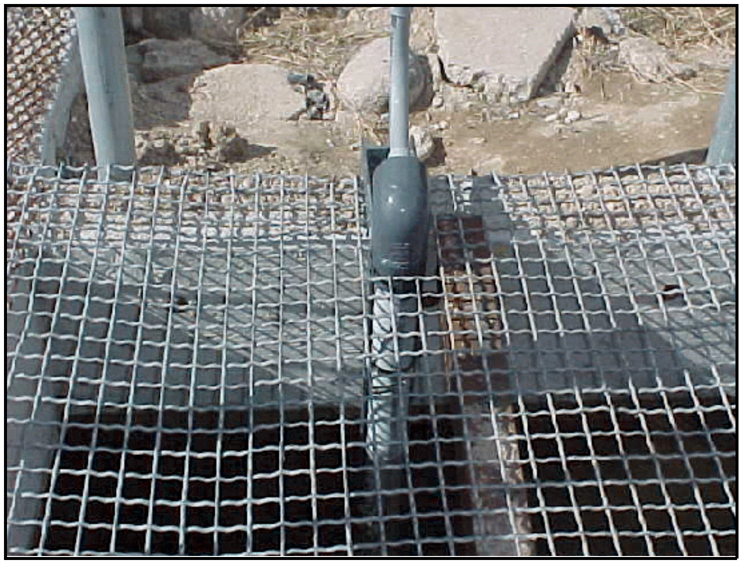


Figure 2.—PVC pipe used to mount the water level sensor. This pipe has the nonsubmersible sensor, but it will be replaced with a submersible sensor in the future.

The prototype AFT that was assembled and tested in the laboratory used an inexpensive submersible pressure transducer; but, other water-level sensors can be used. In the initial development stages, a string transducer with an attached float was used to sense water level. This type of sensor had problems detecting small changes in water level that resulted from small changes in flow rate. This was due to the hysteresis that is often exhibited by string transducers. In order to avoid hysteresis problems, a pressure transducer was substituted for the string transducer. At first, an inexpensive, nonsubmersible pressure transducer was selected and mounted in a polyvinyl chloride pipe to protect the transducer from contact with the water (Stringam and Frizell, 2000). This transducer had a large operating range and was not sensitive enough to measure small water-level changes. Subsequently, a low-cost submersible pressure transducer was selected for the application. The submersible transducer cost less than $270 and is ideal for the AFT. Although the submersible transducer works well for the AFT, other water-level sensors may also be used (i.e., a bubbler or ultrasonic sensor). All that is required is that these sensors output a signal (4-20 milliamp or 0-5 Vdc) that is compatible with the CPU (figure 2).

A prefabricated ramp flume was used for flow measurement with the prototype AFT. This flume has a variety of flow capacities depending on the positioning of the crest. Although a ramp flume was used with the prototype system, other structures may also be used to measure flow rate, or the CPU can be programmed to control a downstream water level.

The turnout gate used on the prototype AFT was a simple, low-cost gate manufactured by a company in Arizona. The original gate was fabricated with a simple hand crank, but it was easily modified to accommodate a linear actuator. The hand crank was left on the AFT because it gave a good visual indication that the gate is moving, and it can also be used to provide backup operation in case the linear actuator fails to operate. If the linear actuator fails, two bolts can be removed, and the hand operator can be used to move the gate.

The actuator is a mass-produced product that was originally designed to move satellite dishes (figure 3). It is relatively inexpensive, readily available, and has limit switches and a position sensor mounted internally. This reduces the cost of the AFT because fabrication costs are reduced and additional components are not required. This actuator has a maximum operating span of 0.6 meter and can exert an operating force of 273 kilograms. It has been well suited for the application because all of the sites have gate movements that are less than 0.6 meter.

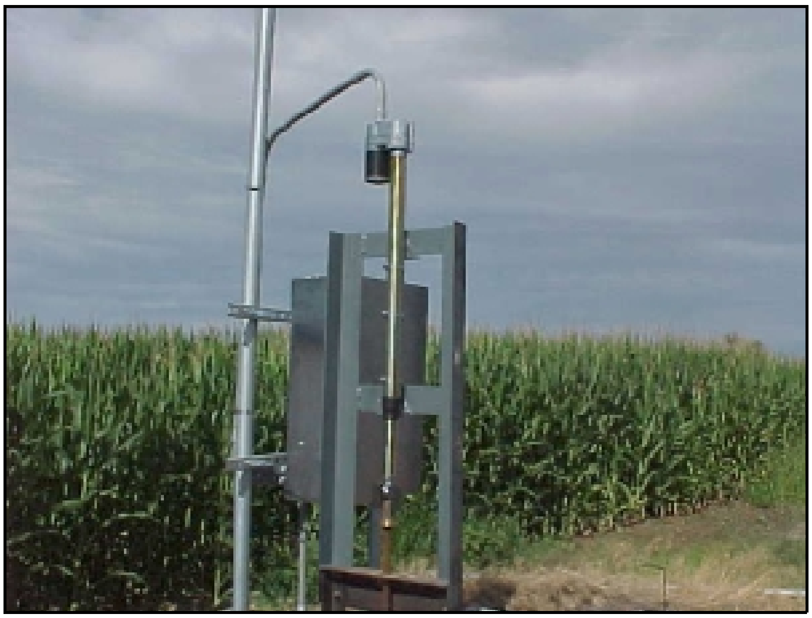


Figure 3.—The linear actuator that is used to move the turnout gate. This turnout uses a waterman gate.

The controller and the gate actuator require a power source which, in many cases, can be satisfied with a solar panel and battery. A 45-watt solar panel was selected for the field demonstration systems and so far seems to meet the power requirements. A 12 Vdc, 100 amp. hr. deep cycle battery was selected to store energy for night time operation or for operating on a cloudy day. A voltage regulator was added to the system to prevent the solar panel from overcharging the battery. If AC power is readily available at the site, this could be used instead of solar power. The cost of an AC to DC power converter is significantly lower than purchasing a solar panel; however, a DC battery is still recommended for this type of power supply to ensure operation if the AC power supply is interrupted. A breakdown of the estimated AFT costs can be seen in table 1.

Other electrical components are required for the controller to operate the gate—relays, manual switches, and terminal blocks. The relays allow signals from the controller to operate the actuator, while the manual switches allow the operator to override the controller and manually move the gate (figure 4). The terminal blocks are used to make connections between the different components. The controller and electrical devices are housed in a standard fiberglass NEMA 4 weatherproof enclosure, which is available from numerous vendors.

Table 1.—Cost of parts for the automated farm turnout

Part	Estimated cost ($)
Gate	250
Controller (CPU)	420
Flume	500
Water-level sensor	300
Linear actuator	160
Control box and electrical parts	250
Solar panel and voltage regulator	350
Battery	100
Total cost of parts	2,280

Note: It is estimated that two person-days would be required for installation.

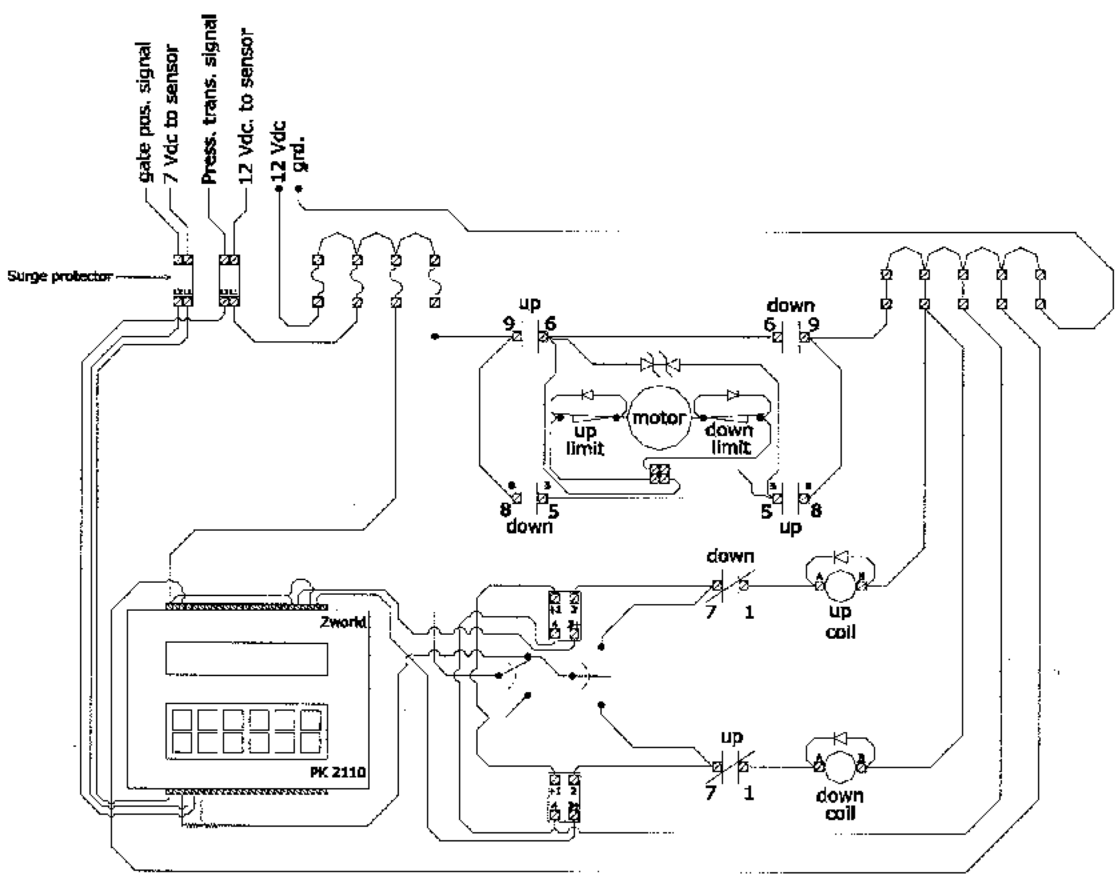


Figure 4.—Wiring diagram for the automated farm turnout.

Field Sites

In addition to the prototype system, demonstration AFTs were developed and installed at three field sites near Boise, Idaho. The farmers who receive irrigation deliveries at these sites fabricated mounting hardware so that an actuator could be mounted on existing turnout gates. The actuator mounting mechanism was simple and easy to construct for these gates. It is believed that it will be compatible with the majority of turnout slide gates.

Two of the three field sites near Boise control water using a flow measurement structure while the third controls water level in the ditch. The flow measurement devices used in the field demonstrations included a sheet metal ramp flume and a Cipolletti weir. If there are no backwater effects due to downstream checks or other controls, the water level can be a relatively accurate indication of flow rate.

The AFT that was installed near Yuma, Arizona, controls water that is diverted into a lateral canal. Water is measured in this canal with a ramp flume. The gate that was already in place was used for this sight, and a larger actuator was required.

AFT Operation

The controller operates using a continuous-loop control program. The controller performs its designed task by first taking a water-level reading from the downstream sensor and computing a flow rate. The controller then compares the computed flow rate or water level against the desired rate or level and determines the difference or error between the two. If there is a substantial difference, the controller estimates a compensating gate movement using a proportional - integral (PI) control algorithm. The gate is then adjusted to bring the flow rate or water level back to the desired value. After the controller makes the gate adjustment, it waits for a period of time and repeats the control operation. The controller repeats the above procedure until the flow or water-level set point is maintained within a predetermined deadband.

The control set point is manually entered into the CPU by pressing one of the buttons on the keypad. When the proper button is pressed, the LCD prompts the operator to enter the desired flow rate set-point value. The set-point is increased or decreased by pressing the up-down arrows on the keypad. Once the desired value is entered, the operator must then press the run key. At this point, the CPU resumes its automatic control function.

The control routine also has the capability of detecting problems such as bad sensors or nonfunctioning gate actuators. If these problems occur, the automatic control function is stopped, and an error is displayed on the LCD.

The turnout flow rate varied from the desired value by as much as 4 percent. This occurred when there were fluctuations in the supply canal and the AFT was in the process of compensating for differences. For most of the steady state operation, the difference between the desired and actual flow rate was less than 1 percent.

Field Test Sites

The AFT has been installed on three farm turnouts near Boise, Idaho (figure 5). Testing of these sites was conducted throughout the latter half of the 2000 irrigation season. An additional AFT was installed in Yuma, Arizona, in the spring of 2001. So far, all system components have functioned properly in the intense summer heat as well as the humidity and dust. The AFTs were left in the field during the nonirrigation season to see how well they endure the winter months. Plans are underway to install this device on other farm turnouts to determine its ability to operate in a variety of canal environments. All of the farmers involved appear to be comfortable with the technology and are capable of maintaining most of the components in the system. It also appears to be beneficial to have the farmers participate with the installation so that they are familiar with the system and how it works.

Figure 5.—The complete AFT unit. The gate diverts water to the right over a Cipolletti Weir. The water then runs down the vertical culvert into a piping system.

Conclusions

The AFT was easily installed in the laboratory and four field sites. As field personnel became more familiar with the device, the installation time was reduced significantly. All of the components in the AFT are performing their required tasks as desired. In all three of the Boise sites, the farmers participated in the AFT installation. All of the farmers have been comfortable with the AFT and are looking forward to the next irrigation season to further test the system. Development and testing of the AFT is ongoing, but initial tests indicate that it is functioning well. Field evaluations are scheduled to continue through the next irrigation season.

References

Stringam, B.L. and K.H. Frizell. 2000. "Irrigation Flow Measurement - Instrumentation Development Part II." Operation and Maintenance Bulletin No. 193, U.S. Department of the Interior, Bureau of Reclamation, Denver Colorado.

Stringam, B.L., D.C. Rogers, and W.R. Walker. 1999. "Designing Reliable Canal Automation Projects - Lessons Learned." *Concepts for Modernization of Irrigation Water Delivery Systems*, USCID, Denver, Colorado.

BEDLINER FOR COAL TAR SPOT REPAIRS

If you have ever done spot repairs to coal tar coatings, you know that various safety measures need to be in place before starting even a small repair. Joel Kenney, the powerplant operator at the Los Alamos County Powerplant at El Vado Dam, avoids problems by using a pick-up truck bedliner coating to meet his spot repair needs.

The pick-up bedliner coating and rust treatment must be used in well-ventilated areas, and all other safety precautions related to working in a confined space should be followed.

The initial step of a repair requires maintenance personnel to clean the affected area of any loose coatings and rust and then apply a rust treatment as the primer coat. To finish the repair, personnel use the bedliner coating. A product hardy enough to withstand abuse and weathering in the bed of a truck seems to work for the water released through power penstocks.

This is the first time the coating has been used in this particular application, and it will not be known how well the coating held up until the next unit inspection (*note*: a followup article will be printed regarding the durability of the repair method). Mr. Kennedy (505) 662-8216, or Bob Major in the Albuquerque Area Office (505) 248-5368, can supply more details about the repair longevity and procedures.

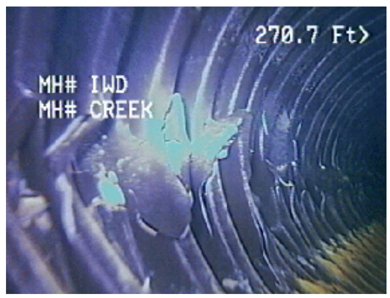
El Vado runner hub after removing loose material.

El Vado runner hub after coating with pick-up bedliner.

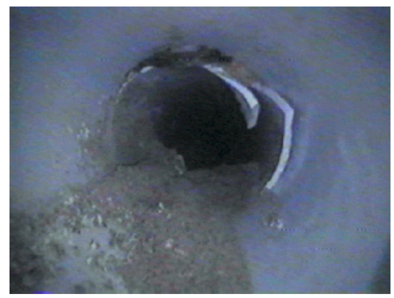
STATUS UPDATE OF THE FLEXIBLE PIPE STUDY TEAM

For the last 15 to 20 years, the Bureau of Reclamation (Reclamation) has been using flexible plastic pipe (mostly HDPE and some PVC) for toe drains and finger drains in earth-fill dams. The Flexible Pipe Study Team (FPST) was formed in January 2001 to assess the possible causes and solutions for recently detected drain failures at a few dam installations (see below). These failures were detected during remotely controlled video inspection.

Davis Creek Dam; 12-inch-diameter HDPE.



San Justo Dam; 18-inch-diameter HDPE.



Washakie Dam; 8-inch-diameter PVC.

In February 2001, the FPST sent out a questionnaire to Reclamation's Technical Service Center (TSC) Principal Designers and Regional Dam Safety Coordinators to gather information on where flexible pipes have been used. The results are currently being compiled, and additional information will be collected as the study progresses. Periodic updates will also be provided.

Since the Spring of 2001, four additional dams with HDPE drain pipe have been video inspected. These video inspections have shown satisfactory performance, with only one short pipe segment displaying shape distortion at one dam installation. Additional video inspections of installations using flexible pipe will be performed in the future as part of Reclamation's video inspection program. These inspections will provide more case history information on the use of flexible pipe.

To date, the study has preliminarily identified three areas of concern:

- Need for periodic remotely controlled video inspection
- Need for pipe resin with better stress-crack resistance
- Need for better compaction and quality control of backfill

Until the FPST has completed their study on the use of flexible pipe, the following interim recommendations are offered:

Remotely Controlled Video Inspection

The following recommendations are offered for designing toe drains, writing specification paragraphs, and performing video inspection.

- Toe drains should be designed to allow for video inspection equipment to traverse the pipe alignment. Video equipment used for pipes with diameters less than 16 inches generally are not steerable. This means that the video equipment can follow the drain alignment, but cannot be navigated about corners, tees, or junctions. Special consideration by the designers should be given to the pipe alignment and the location and number of manholes/cleanouts. Additional toe drain design requirements for accommodating video inspection equipment can be obtained from Chuck Cooper, D-8130; (303) 445-3262.

- Given the recent concerns with flexible pipe, suggest adding a preliminary video inspection when 3 to 5 feet of backfill has been placed over the pipe. The purpose for this inspection would be to identify and repair any abnormalities, cracks, bulges, etc., early before construction is completed.

- Suggest performing another video inspection when the final backfill loading over the pipe is completed. Video inspection should be performed before pulling the torpedo-shaped plug or pig through the pipe and prior to any cleaning. The purpose for this inspection would be to identify any abnormalities, cracks, bulges, etc., that may have developed since the preliminary inspection. Video inspection could replace the need for pulling the plug or pig through the pipe.

- Toe drains should be video inspected after cleaning to ensure they have been cleaned and that no damage has occurred to the pipe during cleaning. This would mean performing video inspections three times for new pipe installations (shallow cover, full cover, and after cleaning). The video inspection performed after cleaning will become the record copy. This record copy will serve as a baseline to compare any changes in conditions observed during future video inspections.

- Video inspections can be done by the TSC's video equipment or by a contractor. If a contractor does the inspection, a Reclamation representative should be watching the video monitor along with the camera operator so that any areas of concern can be fully assessed at the time the video inspection is being performed.

- Reclamation’s field staff and the contractor need to make a strong effort to document alignment (x, y, z) during construction. Experience has shown it is increasingly difficult to accurately locate toe drain pipe alignments as the depth of backfill increases. This becomes especially important if repairs are required on the toe drain pipe. Also, repairs might be performed by someone else sometime in the future.

- To simplify viewing of videotapes, suggest no more than one reach of pipe (manhole to manhole) be put on a single videotape. This eliminates to need to go through hours of toe drain videotape to get to a particular spot.

- Request at least four copies be made of each videotape. One each for the contractor, Contracting Officer, Team Leader, and the TSC Records Office. Copies made from the master tape are always better quality than copies made from copies. For the record copy, the use of a DVD or CD provides for a longer lasting storage media over a videotape.

Resin

Many of the failures appear to be stress cracking of the HDPE drain pipe. Stress cracking is failure (cracking) which develops over time at stresses less than the yield strength. HDPE pipe resins have differing amounts of stress crack resistance (SCR). Not surprisingly, resins with better SCR tend to be more expensive (up to 50 percent higher resin costs).

Three manufacturers (ADS, Hancor, and Prinsco) produce almost all the HDPE drain pipe used by Reclamation. Specifications typically require the drain pipe to meet AASHTO, ASTM, or Reclamation standards. All these standards are very similar, and we are moving toward standardizing on AASHTO. The manufacturers claim that their pipe does not have a problem with stress cracking *"if properly installed."* Proper installation includes good compaction and quality control of the backfill with good support under the haunches. Poor installation can lead to excessive pipe deflection and stress concentrations at the crown, invert, or springline. These stress concentrations make the pipe vulnerable to stress cracking.

Over the past couple of years, Dr. Bob Koerner (Geosynthetics Institute at Drexel University) has been performing research for the Department of Transportation to assess the performance of corrugated HDPE drain pipe in highway applications.[1] His work has shown that AASHTO drain pipe often stress cracks because installation deficiencies cause excessive pipe wall stresses. Since installation deficiencies cannot be eliminated completely, AASHTO is adopting a new SCR criteria effective September 2001.

Under laboratory conditions, HDPE pipe resins with poor SCR can fail within a few hours (less than 10) at relatively low stress levels. HDPE resins with good SCR should not fail before 24 hours, and HDPE resins with excellent SCR do not fail for thousands of hours. Effective September 2001, AASHTO HDPE drain pipe will have to meet the 24-hour SCR requirement when tested in accordance with ASTM D-5397. The old AASHTO standard determined SCR per ASTM D-1693, which had many deficiencies, has been abandoned. Only drain pipe manufactured after September 2001 per the new AASHTO standards should

[1] NCHRP Report 429 "HDPE Pipe: Recommeded Material Specifications and Design Requirements," National Cooperative Highway Research Program Transportation Research Board, 1999 .

be used. If drain pipe manufactured before September 2001 must be used (perhaps because of limited availability and a tight construction schedule), extra care should be taken with the backfill to assure full support and to minimize pipe wall stresses.

Pressure Pipe Resin.—While most manufacturers make single- and double-wall HDPE pipe to the AASHTO standards, a couple of manufacturers (Fusion-Seal and Spirolite) produce pipe that far exceeds the AASHTO standards. The main differences include higher pipe stiffness for deep burial and higher SCR to withstand higher stresses in the pipe wall. This pipe is made using a pressure pipe resin that is about 50 percent more expensive than the normal resin. Use of this higher cost pipe seems warranted for critical applications such as dams and especially warranted for deep burial where the pipe cannot easily be repaired or replaced.

Backfill

Reclamation has a long history of successfully using HDPE and some PVC drain pipe in agricultural drains. These agricultural drains are typically buried 5 to 10 feet deep and are considered noncritical because of the low consequence of failure and the shallow burial (ease of access for repair). Backfill requirements are not very stringent because the gravel envelope is excellent backfill material and is simply dumped into place around the drain pipe with little to no additional compaction.

For dam applications, more stringent backfill requirements are probably needed because of the critical nature, the different backfill materials, and the deeper burial, up to 60 feet. The deeper burial results in higher loads and makes the pipe inaccessible for future repairs. The backfill requirements should be similar to pressure pipe installations. Support under the pipe haunch is especially critical. If the drain pipe is not well supported by the backfill, the pipe will deflect excessively, and stresses are usually concentrated at the crown, invert, or springline. These stress concentrations can lead to premature failure, especially if the pipe does not have sufficient SCR.

Some of the failures detected during video inspection could be isolated point loads from construction loading such as equipment crossings. Depending on the pipe diameter and equipment loads, 1 to 3 feet of compacted cover is required at equipment crossings. Adequate trench width is also important to allow access for compaction equipment.

If you have any questions concerning the flexible pipe study, you may contact any of the team members. The FPST is comprised of John Cyganiewicz (D-8311), phone: (303) 445-3025; Chuck Cooper (D-8130), phone (303) 445-3262; Richard Fuerst (D-8140), phone: (303) 445-3118; Glen Sanders (D-8550), phone: (303) 445-2514; and Jay Swihart (D-8180), phone: (303) 445-2397.

HIGH-PRESSURE SIPHON REPAIR – ROGUE BASIN PROJECT

by Jim Witt, Assistant Manager, Talent Irrigation District

Upon starting the irrigation season in April 2000, a leak was discovered in the high-pressure Billings Siphon which transfers water from the East Canal to the West Canal (approximately 1.25 miles across the valley). This line is a 30-inch, pre-stressed mortar-lined, steel concrete-coated pipe. The design capacity of this siphon is 32 cubic feet per second (cfs). The leak was in an area that has some springs and is directly above the Port of Entry at Ashland, Oregon (on the Interstate 5 Freeway), and was approximately 1.5 cfs. Because of its location, and because the Port of Entry has a drain system surrounding the facility, the leak appeared to have been undetected in the prior season.

Once the leak was detected in the Billings Siphon, repairs began immediately to ensure that water would be distributed to 2,300 acres of land and that there would be no safety hazards because of the depth of the line. The line was approximately 15 feet deep and in very saturated clay soil. The excavation to expose the line took almost 1 day because the Talent Irrigation District had to lay the side slopes of the excavation back to ensure that a cave-in would not occur. Approximately 200 cubic yards of material was removed in this process.

Damaged area exposed before bank sides have been laid back.

After exposing the line, it was found that a rock in the original backfill had fractured the cement mortar outer coating directly adjacent to a joint in the pipe; moisture caused the joint to rust from the outside, causing it to fail.

Damaged joint exposed.

Damaged joint showing rusted area.

A cut out damaged joint.

To complete this repair, the joint had to be cut out and a section welded into the pipe. To accomplish this, the cement mortar outer covering had to be removed back to a point that allowed room to work. Air impact chisels worked well for this procedure. The next step was to expose solid pipe that could be welded to; this meant cutting out an approximate 1-foot section of the pipe. A local tank manufacturer rolled a 15-inch section of 1/8-inch plate to the outside diameter of the pipe. The ring was then cut into two sections to allow the district to install it on the pipe. The half sections were placed on the pipe and held in place with a come-a-long to reduce warping while being welded. A chain was placed around the pipe, and a port-a-power was used to put pressure directly on the area being welded. Shorter sections were then welded and alternated from side to side to keep warping to a minimum. The welding was done with a portable wire feed.

Once both halves were welded into place, the next step was to gain access to the inside of the pipe in order to replace the mortal lining. Holes were cut, and 4-inch, high-pressure couplings at 12, 4, and 8 o'clock were welded into place around the pipe. This allowed the crew to reach inside and coat the inside bonding agent which would allow the mortar to stick. Then, the fast-set mortar was mixed with the bonding agent, which makes up about half the moisture content in the mixture, with water being used for the remainder. This made the mortar sticky and easy to keep in place on the crown of the pipe. The mixture was applied with a sponge trowel. With the inside now coated with mortar, 4-inch plugs were installed in the couplings. Both the plugs and couplings were black iron and coated in zinc chromate primer. The same mortar mix that was used to coat the inside of the pipe was also used to coat the outside of the pipe.

Repair sections clamped in place before welding.

The pipe was pre-stressed with a wire wrapped around it. Once the outside mortar set, the pre-stressed wire was rewound around the pipe and the two ends pulled tight together. The ends were held in place with vice grips while lap welding. The repair was now complete.

Completed repair before final backfilling. Notice the access plug at the 12 o'clock position to facilitate interior pipe coating. Two other plugs are located at the 8 and 4 o'clock positions.

To accomplish the backfill, the excavation was closed and compacted to within about 2 feet of the repair. The area adjacent to the pipe was left open. The area under the pipe was left undisturbed. A 1.5 sack slurry mix was poured into the open area around the pipe and up the sides to the top one-third of the pipe. This was left open for 24 hours. The line was then charged.

The Billings Siphon at the point of repair has approximately 70 pounds per square inch (lb/in^2) and approximately 150 lb/in^2 total on this line. Since the time of the 3-day repair, there have been no reported problems.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The purpose of this bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful operation and maintenance ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin—let us hear from you soon!

Prospective articles should be submitted to one of the Bureau of Reclamation contacts listed below:

Jerry Fischer, Technical Service Center, ATTN: D-8470, PO Box 25007, Denver, Colorado 80225-0007; (303) 445-2748, FAX (303) 445-6381; email: jfischer@do.usbr.gov

Vicki Hoffman, Pacific Northwest Region, ATTN: PN-3234, 1150 North Curtis Road, Boise, Idaho 83706-1234; (208) 378-5335, FAX (208) 378-5305

Steve Herbst, Mid-Pacific Region, ATTN: MP-430, 2800 Cottage Way, Sacramento, California 95825-1898; (916) 978-5228, FAX (916) 978-5290

Albert Graves, Lower Colorado Region, ATTN: BCOO-4846, PO Box 61470, Boulder City, Nevada 89006-1470; (702) 293-8163, FAX (702) 293-8042

Don Wintch, Upper Colorado Region, ATTN: UC-258, PO Box 11568, Salt Lake City, Utah 84147-0568; (801) 524-3307, FAX (801) 524-5499

Dave Nelson, Great Plains Region, ATTN: GP-2400, PO Box 36900, Billings, Montana 59107-6900; (406) 247-7630, FAX (406) 247-7898